The Research of Fuzzy-controller Designing based on Tobacco-baking Control System

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Abstract
In the process of tobacco baking, the temperature and humidity are characteristic of time-varing, large delay and nonlinear, which make the controlling effect of conventional control methods unsatisfying. Recently, the fuzzy control method has been applied in various fields of natural science and social science, and fuzzy control has become an important branch of intelligent control. In this paper, we utilize fuzzy control method, and combine it with the fuzzy math and performance of tobacco-baking, fuzzy language and fuzzy logic rules, designing the fuzzy controller to make the tobacco-control system adaptive and robust. This method realizes the accurate control on the temperature the curing time the tobacco leaves baking, and the system achieve the functions of temperature and humidity automatically check, and the sectional control of temperature and humidity.
Key words: TOBACCO BAKING CONTROL SYSTEM, FUZZY CONTROL, CONTROLLER, DESIGN

1. Introduction

Since the creation of fuzzy set theory by Zadeh in the University of California[1] and the application of fuzzy control in oiler and stream engine control by E.H.Mamdani in 1974[2], the fuzzy control is widely developed and applied. From the interpolation mechanism of fuzzy control, Hongxing Li reveals that the essence of fuzzy controller is a kind of interpolation device, and the design idea of basic range reduced fuzzy controller is introduced[3,4]. Later, some scholars use the theory of changeable discourse of universe to design the controller successfully and apply it to practice[5]. In the production of flue-cured tobacco, the tobacco baking is a very important part, in order to ensure the quality of tobacco baking, it is required to control the temperature and humidity. In the traditional automatic control system, the integrated design of the controller is based on the accurate mathematical model of the controlled object[6]. The barn temperature and humidity is of time-varying, therefore, the tobacco control system is characteristic of ambiguity and complexity, and it is difficult to establish a precise mathematical model when using conventional control methods to control. And the fuzzy controller is the core of fuzzy control systems, its performance depends on the fuzzy control rules. The tobacco-baking system is based on the experience of the operators to control the system, it is not necessary to establish an accurate model of the controlled object, which is a method to solve uncertainties of flue-cured tobacco control system.

2. Structure design of fuzzy controller

Operators hold the experience of the manual control strategy through learning, testing and long-term observing , which can be described by the natural language. Fuzzy controller (FC-Fuzzy Controller) is to achieve fuzzy control [7], which is the development of a new type of language controller on the basis of the concept of linguistic variables being used as a description of manual control strategies, and fuzzy controller is assorted into the single variable fuzzy controller and the multiple variable fuzzy controller.

The conventional fuzzy controller is kind of single variable fuzzy controller with an independent external input-variable, the dimension of single-variable fuzzy is the number of controller fuzzy input. The most widely used is a two dimensional fuzzy controller, its input is the error E and the change rate of error EC, and the output is controlling variable U. According to the characteristics and requirements of the flue cured tobacco control system in the research two-dimensional structure is chosen, which means that the error of temperature and humidity, and the error changing rate are as the input variables. The basic structure is shown in figure 1.

There are two main types for temperature control in the process of tobacco baking: one is constant temperature control, the one is even temperature control. In the figure1, E_t is temperature error, Eh is the humidity error, Et' is the temperature error changing rate, E_h' is humidity error changing rate. δ1 and δ2 are temperature and humidity decoupling coefficients, C_t is the controlling variable of heating, C_h is the controlling variable of drying, C_t is finally quantified into the speed of the blower, C_b is finally quantified into air door opening degree, which includes the number of step motor, the turning speed of exhaust fan and circulating fan.

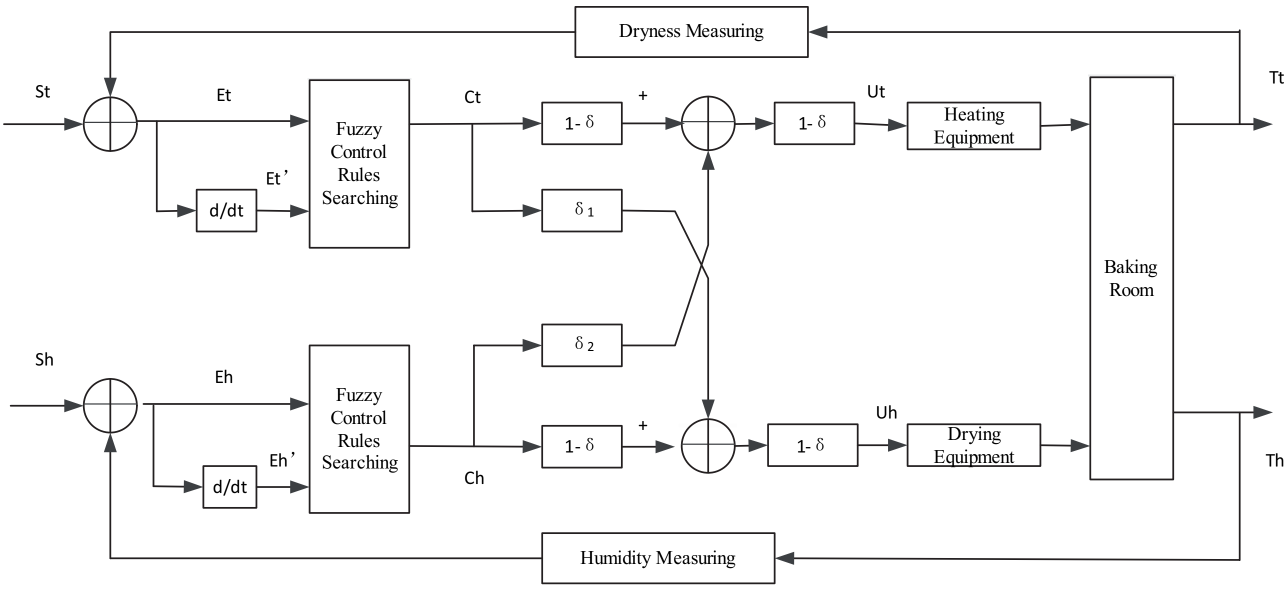

Figure 1. Structure of fuzzy controller

3. Variables fuzzification

In practical applications, generally the input and output are accurate . The input and output variables of the fuzzy control system are called linguistic variables, the accuracy of the input is fuzzy-processed into fuzzy quantity, which means that the input variable language value is transformed to the corresponding membership degree according to the membership function[8].

In the process of fuzzy, there is a range of the actual changes in the input, which is called the basic range. Supposing the basic range of error is [-E, E], the basic range of error rate is [-CE, CE], and the range of fuzzy set is X=[-N, -N+1,... O... , N-1, N], N is the level of error quantity ranging from 0~E. The [-E, E] and [-CE, CE] are transformed to the fuzzy set range to be discussed, then the fuzzy subset is formed in the linguistic variable values. In actual control system, the change of error and error change rate is generally not in the range X, it has to be multiplied by proportional coefficient, known as quantization factor. In the fuzzy reasoning, the error's quantization factor K_E is:

$$k_E = \frac{N}{E} \tag{1}$$

quantization factor of error changing rate is K_{CE}

$$k_{CE} = \frac{N}{CE} \tag{2}$$

Set the system control variables as U, the basic range of U is [-U, U], and N is the level basic range. Based on the concept of quantization factors, its quantization factor is K_U

$$k_U = \frac{U}{N} \tag{3}$$

From the quantization factor in the formula (1), (2), (3), it can be obtained that once the level of basic range or the range is confirmed, the value of the quantization factor can make the basic range reduced or enlarged, which means the basic range will enlarge when the quantization factor become big, and vice versa. In this way, the sensitivity of the control effect is greatly reduced. Because the selection of the quantization factor is limited, it can not guarantee the whole stage of the process of the controlled process is in the best control state, so the robustness of fuzzy control system will be reduced. In order to solve this problem, the variable factor which is implemented by the array quantization factor, or adjusting KE, KCE and K_U, in different states is used.

The fuzzy subsets of the linguistic variables are described by the membership function[9]. Therefore, the accuracy of the fuzzy decision is determined by the value of the membership function, the shape of the membership function curve is higher, and the system stability is relatively good. The system stability is relatively good, and the Gauss type membership function is used. According to the control accuracy and the actual testing conditions of the baking room requirements, the flue cured tobacco control system collects the real-time data of baking room every five minutes, and summarizes the data, set the temperature error of the basic Et is [-6, 6, -5, -4, -3, -2, -l, 0, l, 2,3,4,5,6}, so the quantization factor K_{Et}: $K_{Et} = 6/6 = 1$. Division of temperature error of fuzzy quantities are seven levels: negative big, negative middle, negative small, zero, positive small, positive middle, positive big, respectively represented by NG, NM, NL, PZ, PL, PM, PG.

In this system, the temperature error of the fuzzy membership function is described by the Gauss type function. The value of the Gauss function M is -6, -4, -2,0,2,4,6. σ is 1.4. They are defined in the fuzzy set range {-6, -5, -4, -3, -2, -l, 0, l, 2,3,4,5,6}:

$$\text{NG: } \mu_{NG} = e^{-\left(\frac{x+6}{1.4}\right)^2}. \tag{4}$$

$$\text{NM: } \mu_{NM} = e^{-\left(\frac{x+4}{1.4}\right)^2}. \tag{5}$$

$$\text{NL: } \mu_{NL} = e^{-\left(\frac{x+2}{1.4}\right)^2}. \tag{6}$$

$$\text{PZ: } \mu_{PZ} = e^{-\left(\frac{x}{1.4}\right)^2}. \tag{7}$$

$$\text{PL: } \mu_{PL} = e^{-\left(\frac{x-2}{1.4}\right)^2}. \tag{8}$$

$$\text{PM: } \mu_{PM} = e^{-\left(\frac{x-4}{1.4}\right)^2}. \tag{9}$$

$$\text{PG: } \mu_{PG} = e^{-\left(\frac{x-6}{1.4}\right)^2}. \tag{10}$$

The basic range of setting humidity error is [-4,4], and the fuzzy set of the humidity error is {-2, -1,0,1,2}, the quantization factor K_{Eh} is:

$$K_{Eh} = \frac{2}{4} = 0.5. \tag{11}$$

The humidity error of fuzzy value include negative big, negative small, zero, is positive small, positive big five levels, respectively represented by NG, NL, PZ, PL, PG. In this system, the fuzzy membership function of the humidity error is also described by the Gauss type function. They are defined in the function of fuzzy set range {-2, -l, 0, l, 2},(5)-(11). The value of Gauss function M is -2, -1,0,1,2, σ is 1.4. The fuzzy relational matrix is:

$$R_t = \prod_{i=1}^{k} r_i = r_1 \bigcup r_2 \bigcup r_3 ... \bigcup r_k,\ k = i \cdot j. \tag{12}$$

$$S_h = \prod_{i=1}^{k} s_i = s_1 \bigcup s_2 \bigcup s_3 ... \bigcup s_k,\ k = i \cdot j. \tag{13}$$

and

$$r_i = E_t(i) \cdot E_t'(j) \cdot C_t(i,j),\ i = 1 \sim 4,\ j = 1 \sim 4 \tag{14}$$

$$s_i = E_h(i) \cdot E_h'(j) \cdot C_h(i,j),\ i = 1 \sim 4,\ j = 1 \sim 4 \tag{15}$$

The corresponding fuzzy control output is:

$$C_t = (E_t \times E_t') \times R_t \tag{16}$$

$$C_h = (E_h \times E_h') \times R_h \tag{17}$$

4. Output fuzzification

In the control system, according to the control system the actual need, we select burrows, blowers, skylights, circulation fans, blinds as [10]. There are only two kinds of States, which are open and closed, but in the actual process of baking, it can be controlled based on the different stages of the baking and baking room's temperature. According to the different angle of the skylight, the skylight is divided into four grades: small open (1/3), middle open (2/3), totally open, respectively represented by PZ, PL, PM and PG.

The main function of the burrow is dehumidifying and cooling the bake room, and 0 means open, 1means closed. The blower's main task is to heat and do heat insulation, when the temperature can not meet the requirements of the heating, the system of fuzzy control strategy is to imitate the human thinking, which means when the temperature difference is larger, make the blower circulate air strongly, and when the temperature difference is small, we reduce the circulate air, the air blower is divided into four levels, the corresponding fuzzy language is PL, PM, PZ and PG. The main function of the circulating fan is to ensure the consistency of the upper and lower shelf temperature, and it will be designed as switch signal controlling and 0 means open, 1means closed. The blinds is dehumidifying and cooling, which is controlled by switch signal, 0 means open, 1means closed. Blower and skylights are divided into four grades. The fuzzification of the membership functions are still using the Gaussian function, fuzzy set range is {0,1,2,3,4,5,6}, and fuzzy quantity is divided into four grades: PZ, PL, PM and PG, the M is value of 0,2,4,6, and σ is 1.4. So the skylight and blower in the range {0, l, 2,3,4,5,6} in the Gauss function is defined as forumla (7) - (10).

5. Establishing of fuzzy control rules

In essence, the fuzzy control rule is a collection of fuzzy conditional statements [11], which will be summarized as the practical experience of the operator in the process of baking. The control rules of the fuzzy controller are described by a set of fuzzy conditional statements which are connected with each other by the "or". The fuzzy control rules of the system are as follows:

If E_t=PG and E_t'=PL then U=NM;

If E_t=PG and E_t'=PL or E_t'=PM then U=NG;

According to this, if the fuzzy value of temperature error and the error change rate of the temperature are obtained, the fuzzy control value can be obtained according to the actual baking experience. The process of fuzzy relational equation solving, by the fuzzy control rule and fuzzy input value, to get fuzzy control value is fuzzy reasoning [12,13]. The result of fuzzy reasoning is still a fuzzy value, which needs to be transformed into an accurate amount of execution mechanism by fuzzy decision. There are five main actuators in tobacco baking room, including burrow, skylight, circulating fan, blower, blinds. Combined with actuators and its effect on the environment of the baking room, we propose combination of the housing environmental condition regulation, which are in table 1.

Table 1 housing environmental condition regulation

sequence	skylight	blinds	burrows	blower	Circulating fan	temperature	humidity
1	1	1	1	0	0	↓↓↓↓↓	↓↓↓↓↓
2	1	1	0	0	0	↓↓↓	↓↓↓
3	0	0	0	1	0	↑↑↑	--
4	0	0	0	1	1	↑↑↑↑↑	↓
5	0	0	1	0	0	↓	↓↓
6	0	1	0	1	0	↑	↓
7	0	0	0	0	1	--	--

In the table1,1 means actuators totally open, and 0 means actuators totally closed. ↑ means Increasing, ↓ means decreasing, whose degree is represented by number. – means unchanged. The control rules are described by "if... Then..." form conditional statement. When the fuzzy control rule table is established, the selection principle of control quantity is: when the error is large, the selection control is used to eliminate the error as soon as possible [14,15]; when the error is relatively small, the choice of the control is mainly used to prevent the overshoot in order to ensure the stability of the system. When temperature and humidity control is contradictory, the control temperature is preferred.

6. Conclusions

The fuzzy control is a kind of computer numerical control based on fuzzy set, fuzzy linguistic variable and fuzzy logic reasoning. From the point of view of nonlinear control and linear control, the fuzzy control is a nonlinear control; from the view of intelligence of the controller, the fuzzy control is a kind of intelligent control, and it has become an important and effective form of intelligent control.

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Research on a Fast Algorithm for Mining Association Rules Based on Vertically Distributed Data in Large Dense Databases

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Abstract
In this paper, we prompt a new a fast algorithm for mining association rules based on vertically distributed data in large dense databases. In order to calculate item sets support, this paper puts forward the concept characteristic matrix and characteristic vector, and emerges an algorithm for mining association rules based on the characteristic matrix. As a result of drawing the advantages of CARMA(continuous association rule mining) algorithm,the algorithm needs to scan the database for only twice. Experimental results show that the algorithm is correct,and in the large dense transaction databases, VARMLDb algorithm has higher implementation efficiency.
Keywords: MULTI NODE COOPERATE. FAST ALGORITHM, MINING ASSOCIATION RULES, VERTICALLY DISTRIBUTED DATA, LARGE DENSE DATABASES